Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE. E. L. MARK, DIRECTOR.—No. 184.

THE OPTIC CHIASMA OF TELEOSTS: A STUDY OF INHERITANCE.

By A. P. Larrabee.

Presented by W. E. Castle. Received June 28, 1906.

Introduction.

In the majority of teleosts, as has been pointed out by several investigators, the condition of the optic chiasma is markedly different from that found in other vertebrates. In these teleosts the nerve fibres of the two optic nerves do not interlace at the chiasma, but each nerve remains distinct, so that the two can easily be dissected apart at that point. Conflicting statements regarding the condition of the chiasma are found, some writers stating that the nerve running to the right eye is dorsal, others making the opposite statement. In recent years Parker (:**03**) has shown that one condition is about as common as the other. He made a dissection of one hundred specimens, each of ten different species of symmetrical teleosts. Of these, 514 had the right nerve dorsal and 486 the left nerve dorsal. In each case the right or left nerve signifies the nerve running to the right or left eye respectively. He showed, too, that this dimorphism is not correlated with sex. To quote from his paper giving his conclusions on this point: "In Fundulus, of the 51 specimens with the left nerves dorsal, 29 were females and 22 males; and of the 49 with the right nerves dorsal, 29 were females and 20 males. Of the 43 specimens of Tautogolabrus with the left nerves dorsal, 26 were females and 17 males; and of the 57 with the right nerves dorsal, 26 were females and 31 were males. These figures show clearly that there is no close correspondence between the crossing of the optic nerves and sex."

The question whether this dimorphism is due to racial differences was left undecided. The writer will presently answer this question in the negative, and at the same time discuss the relation of the dimorphism to heredity, and in the brook trout the effects of altered action of gravity during development, together with the results obtained from the study of monstrous specimens and from the development of the optic nerves. The work on the inheritance of the optic chiasma was begun by Dr. W. E. Castle and Mr. F. E. Pomeroy, and was carried on and completed by the writer under the direction of Dr. Castle, to whom the writer wishes to acknowledge his great indebtedness for the material placed at his disposal and for aid and criticism during the progress of his studies. He is also grateful to Mr. Pomeroy for the use of results obtained by him at the beginning of this investigation. Thanks are due also to the Massachusetts Commissioners of Fisheries and Game, and in particular to Mr. Arthur Merrill, superintendent of the fish-hatchery at Wilkinsonville, Massachusetts, for supplying and rearing the brook trout material; also to the officers of the Bureau of Fisheries of the United States Department of Commerce and Labor who supplied and reared at Wood's Hole, Massachusetts, the young codfish used.

Object of the Investigation and the Method employed.

The writer has already hinted at the object for which this investigation was undertaken. The main object was to test the relation of heredity to the dimorphism of the chiasma, and especially to determine the applicability of Mendel's Law, should heredity prove to be a factor in this dimorphic condition. In order to determine whether or not heredity is a factor, matings of selected individuals were made, and the effects determined by dissecting the young. For this purpose two species of fish were used, the common brook trout (*Salvelinus fontinalis* Mitchill) and the codfish (*Gadus morrhua* L.). Since the spawning season of these two is mainly during the months of November and December, they were especially convenient forms with which to work. In making these matings, the eggs of a female were commonly divided into two or three lots, and each lot fertilized artificially with the milt of a different male. The parents were then dissected to determine the position of the nerves in the chiasmata; the different lots of eggs were carefully marked, and the necessary data recorded for future use. This part of the work was done by Dr. Castle; the study of the first generation of brook trout and of the first lot of young codfish was begun by Mr. Pomeroy and completed by the writer, who also carried out the remaining studies described in this paper and prepared this report for publication.

In preserving the two species of fish for study, different methods of fixation were found necessary. The young trout were of sufficient size to allow dissection with needles under the dissecting microscope. They were killed and fixed in Kleinenberg's picro-sulphuric solution, washed out in 70 per cent alcohol, and finally preserved in 85 per cent alcohol. The young cod were too minute to be dissected in the same way as the trout. It was necessary, therefore, to imbed these in paraffine, and section, using the compound microscope to follow the course of the optic nerves. Vom Rath's platinic-osmic-acetic fluid was found to be the best fixative for use with the cod.

Throughout this paper the writer will designate the optic nerves according to the method employed by Dr. Parker, that nerve being named *right* which runs to the right eye; the one to the left eye, *left*. For convenience, too, the specimens with the right nerve dorsal will be termed *rights*, and similarly those with the left nerve dorsal, *lefts*.

Results of Selected Matings in the Brook Trout (*Salvelinus fontinalis* Mitchill).

First Generation.

The first generation of the trout includes the young regarding which the condition of the chiasmata of one or both parents, but not of the grandparents, was known. The results obtained from this generation are shown in Tables I, II, and III. In all, there are eleven lots, four of which were obtained in 1901, the remaining ones in 1902. In each year where a male or female was used for more than one lot, the fact can be recognized by the correspondence of the numbers following the sex signs. The numbers of the two years, however, relate to different individuals. The control lot includes a number of young taken at random from the fry at the hatchery without any knowledge of the condition of the crossing of the nerves in the parents. This lot, comprising young of various parents, is assumed to represent the average condition of the trout in their natural state.

The proportion of rights and lefts found in the eleven lots of the first generation corresponds closely with that obtained from the control lot. The percentage of rights in both cases is practically the same, — 56 per cent. With the exception of two lots, there is a slight excess of rights in each case. In the nine lots where this excess is found, the rights outnumber the lefts by from 0.4 per cent to 20 per cent. The difference between the percentages of rights and of lefts in the series as a whole is 11.8 per cent, which closely approximates the difference of 12.2 per cent found between the two kinds in the control lot. Nothing in the net results indicates that in one case we are dealing with the young of selected parentage and in the other with young taken at random.

Tables II and III show from another point of view the results obtained from the first generation. In Table I the results are given as a whole, but in these two tables the results are grouped according to the condition of the chiasmata in the parents. Lots C and D, 1901, have to be omitted from Tables II and III, as the crossing in the female is not known. In comparing the results in these two tables, it is interesting to note

TABLE I.

RESULTS OF SELECTED MATINGS IN THE BROOK TROUT (*Salvelinus fontinalis* Mitchill).

FIRST GENERATION.

Lot.	Nature of Mating.	Total Number of Young dissected.	Right Nerve[1] Dorsal.	Left Nerve[2] Dorsal.	Per cent R.	Per cent L.
A, 1901	♀$_1$R × ♂$_1$L	792	471	321	59.4	40.6
B, “	♀$_1$R × ♂$_2$R	346	188	158	54.3	45.7
C, “	♀$_2$? × ♂$_3$L	677	380	297	56.1	43.9
D, “	♀$_2$? × ♂$_4$R	798	479	319	60.0	40.0
1, 1902	♀$_1$R × ♂$_1$L	122	62	60	50.8	49.2
2, “	♀$_1$R × ♂$_2$R	105	59	46	56.0	44.0
3, “	♀$_1$R × ♂$_3$L	212	103	109	48.6	51.4
4 “	♀$_2$R × ♂$_1$L	168	91	77	54.1	45.9
5, “	♀$_2$R × ♂$_2$R	420	212	208	50.2	49.8
6, “	♀$_3$R × ♂$_4$R	100	48	52	48.0	52.0
7, “	♀$_3$R × ♂$_5$L	225	126	99	56.0	44.0
Total		3965	2219	1746	55.9	44.1
Control		650	365	285	56.1	43.9
Grand total		4615	2584	2031	56.0	44.0

[1] Nerve to right eye.

[2] Nerve to left eye.

that, although the difference between the two groups is small, yet, in the case of the young whose parents were both rights, the tendency towards equality is slightly greater. In other words, among the young whose parents were both rights, the proportion of rights is smaller than among those which had but one parent with the right nerve dorsal.

TABLE II.

Lots from Table I in which the Condition of the Chiasma was the same (R × R) in Both Parents.

Lot.	Total No. dissected.	Right Nerve Dorsal.	Left Nerve Dorsal.	Per cent R.	Per cent L.
B, 1901	346	188	158	54.3	45.7
2, 1902	105	59	46	56.0	44.0
5, “	420	212	208	50.2	49.8
6, “	100	48	52	48.0	52.0
Total	971	507	464	52.2	47.8

TABLE III.

Lots from Table I in which the Condition of the Chiasma was Unlike in the two Parents.

Lot.	Total No. dissected.	Right Nerve Dorsal.	Left Nerve Dorsal.	Per cent R.	Per cent L.
A, 1901	792	471	321	59.4	40.6
1, 1902	122	62	60	50.8	49.2
3, “	212	103	109	48.6	51.4
4, “	168	91	77	54.1	45.9
7, “	225	126	99	56.0	44.0
Total	1519	853	666	56.2	43.8

It is evident from the close correspondence of the percentages shown in Tables II and III with those of the control lot (Table I), that if the Mendelian principles of heredity can be applied at all to the case of the optic chiasma, it is an example of alternative dominance, for neither condition is uniformly dominant over the other. The results shown in Table III, where the crossing of the nerves was different in the two parents, correspond closely with those to be expected if dominance is alternative. If such is the case, it is necessary to assume either that the parents were a "pure" right and a "pure" left, respectively, or that both were heterozygotes. On the former assumption, the results to be expected from the Mendelian formula would be equal numbers of rights and lefts, all heterozygotes, thus:

$$\begin{array}{l}
R + R = \text{gametes of first parent.}\\
L + L = \text{ ” ” second ” .}\\
\hline
2\ R\ (L) + 2\ L\ (R) = \text{offspring.}
\end{array}$$

If both parents were heterozygotes, the apparent result would be the same, but half each of the right and of the left offspring would be "pure," the other half heterozygous, thus:

$$\begin{array}{l}
R + L = \text{gametes of first parent.}\\
R + L = \text{ ” ” second ” .}\\
\hline
R + R\ (L) + L\ (R) + L = \text{offspring.}
\end{array}$$

If one parent were a pure right and the other a heterozygote, the proportion of rights to be expected would be 75 per cent, thus:

$$\begin{array}{l}
R + R = \text{gametes of first parent.}\\
R + L = \text{ ” ” second ” .}\\
\hline
R + R + R\ (L) + L\ (R) = \text{offspring.}
\end{array}$$

The last assumption evidently is untenable, for in none of the lots studied is this proportion approximated.

This principle of alternative dominance could be applied to the results in Table II only by assuming that both parents were heterozygous. On this assumption alone could the observed almost equal proportions of right and of left offspring be explained.

The first generation furnishes no direct evidence which would allow a positive assumption that the facts are to be explained by Mendel's Law.

Further, the results of the first generation show conclusively that prepotency is not found in any individual. In Lots 1, 2, 4, and 5, 1902, the eggs of two trout were divided each into two lots, making four in all. These were fertilized by two males so as to get as many combinations as possible. The following table (IV) gives the crosses together with the percentage of rights resulting from each:

TABLE IV.

Lot.	Nature of Mating.	Per cent R.
1, 1902	♀$_1$R × ♂$_1$L	50.8
2, "	♀$_1$R × ♂$_2$R	56.0
4, "	♀$_2$R × ♂$_1$L	54.1
5, "	♀$_2$R × ♂$_2$R	50.2

An examination of this table makes it evident that no prepotency is found in any individual or in either sex.

TABLE V.

RESULTS OF SELECTED MATINGS IN THE BROOK TROUT
(*Salvelinus fontinalis* Mitchill).

SECOND GENERATION.

Lot.	Nature of Mating.	Total Number of Young dissected.	Right Nerve Dorsal.	Left Nerve Dorsal.	Per cent R.	Per cent L.
1, 1903	♀$_1$R × ♂$_1$R	39	21	18	53.8	46.2
1a, "	♀$_1$R × ♂$_2$R	8	4	4	50.0	50.0
2, "	♀$_2$L × ♂$_3$L	15	8	7	53.3	46.7
2a, "	♀$_2$L × ♂$_4$L	28	7	21	25.0	75.0
3, "	♀$_3$L × ♂$_5$L	41	21	20	51.2	48.8
4, "	♀$_4$R × ♂$_6$R	19	10	9	52.6	47.4
4a, "	♀$_4$R × ♂$_7$R	20	10	10	50.0	50.0
5, "	♀$_5$R × ♂$_8$R	69	33	36	47.8	52.2
6, "	♀$_6$R × ♂$_9$R	96	51	45	53.1	46.9
Total.		335	165	170	49.2	50.8

RESULTS OF THE SECOND GENERATION.

The second generation of trout (Table V) were descended from Lot B, 1901. This lot included offspring from parents both of which had the right nerve dorsal in the chiasma. The condition of the crossing in the more remote ancestors is unknown, but from the results of the first generation and of the control lot, it may safely be assumed that they were about equally divided between rights and lefts.

The trout used for the second generation were small and immature. Consequently the number of eggs produced was small, and the number of young hatched proportionately smaller than in ordinary lots. Six females and nine males were used. The eggs of three of the females were divided into two lots each, making nine lots in all. The young trout were taken soon after hatching and fixed, as before, in Kleinenberg's picro-sulphuric solution.

TABLE VI.

Group.	Total.	Number of "Rights."	Number of "Lefts."	Per cent R.	Per cent L.
A. (L × L)	84	36	48	43	57
B. (R × R)	251	129	122	51	49

In these nine lots there were 335 specimens, of which 165 were rights and 170 were lefts. These 335 trout can be divided into two groups according to their parentage. Group A includes those whose parents were both lefts; Group B, those whose parents were both rights. The results are summarized in Table VI.

The excess of lefts in Group A at first thought seems significant, but is doubtless due to the smallness of the lot (compare the result given by Lot 2 a, 1903). This lot gave the same proportion (75 per cent lefts to 25 per cent rights) which might be expected were this a case of dominance under Mendel's Law, but the number of young is so small as to make the chances of error very great. Not only the small number included in Group A throws doubt on the significance of the result, but also the results of the larger group (B). In this latter group there are 251 individuals, of which 129 or 51 per cent are rights. We are dealing here with individuals whose parents and grandparents were rights, and yet the result is practical equality of rights and lefts.

When discussing the results of the first generation, the writer stated that if Mendelism applied to this dimorphism, the case must be one of alternative dominance, and the suppositional grounds were stated on which that claim might be based. In discussing the group which included the young of trout both of which were rights, it was stated that both parents must be heterozygotes. Assuming this to be the case, it would follow that of the rights produced in the so-called first generation, one half would be pure and the other half heterozygous, i. e., rights having the left condition recessive. According to the laws of chance, out of a considerable number of these rights, there would be one chance out of three of obtaining a "pure" right. Among the parents of Group B there were four females and six males. Applying the law of chance stated above, it is improbable that out of ten specimens not one should prove to be a "pure" right, — an animal which would give at least 75 per cent of right offspring. These results lead inevitably to the conclusion that the Mendelian principles of heredity do not apply to the dimorphism of the chiasmata of the trout, thus confirming the doubts caused by the results of the first generation.

The trout in Group B, whose parents and grandparents were rights, afford a basis for comparison with the results to be expected from another theory of heredity, namely, the one advanced by Galton ('89). According to this theory, the parents contribute one half the hereditary influences, the grandparents one quarter, the great-grandparents one eighth, and so on.

In Group B there were 251 individuals, whose parents and grandparents were rights. According to the law of Galton, the influence of these more immediate ancestors would be 75 per cent. The remoter ancestors would probably be divided about equally between rights and lefts. This would increase the influence of the rights to 87½ per cent. Of the 251 trout, then, about 87½ per cent, or 219 individuals, should have the right nerve dorsal. Actually there were 51 per cent, or 129 rights. Such a discrepancy as this between the calculated and observed results clearly indicates the inapplicability of Galton's Law.

The results of selective breeding in the trout clearly indicate that neither dimorphic condition is a racial character. All the trout came from the same locality, and although bred to the second generation, no effect of selection on the dimorphism was evident, unless possibly a tendency to make the two conditions more nearly equal.

The Results of Selected Matings in the Codfish (*Gadus morrhua* L.).

The results obtained from the codfish have little significance in themselves, but they serve to confirm the conclusions drawn from the study of the brook trout.

In the examination of the codfish, made by Dr. Parker, 60 out of 100 individuals had the right nerve dorsal. Table VII shows a similar result for several selected matings of different sorts. Comparing this table with Table I, where the results of the first generation of trout are tabulated, a similarity is found with the conditions observed in that species. The range of variation in the percentage of rights is greater in the case of the cod than in the trout. Lot D, 1901, is specially noteworthy. With both parents lefts, there is among the young an excess of rights instead of lefts, as might be expected. From the similarity of results in the two species, the conclusions which were drawn in the case of the trout are made more certain. Selective breeding again fails to bring out any evidence that either condition is hereditary.

TABLE VII.

RESULTS OF SELECTED MATINGS IN THE CODFISH
(*Gadus morrhua* L.).

Lot.	Nature of Mating.	Total Number of Young dissected.	Right Nerve Dorsal.	Left Nerve Dorsal.	Per cent R.	Per cent L.
A, 1901	$♀_1$R × $♂_1$R	241	159	82	66.0	34.0
B, "	$♀_1$R × $♂_2$L	168	113	55	67.3	32.7
C, "	$♀_2$L × $♂_1$R	150	82	68	54.7	45.3
D, "	$♀_2$L × $♂_2$L	249	145	104	58.3	41.7
9, 1902	$♀_4$R × $♂_6$R	142	70	72	49.3	50.7
10, "	$♀_4$R × $♂_7$L	102	52	50	50.9	49.1
Total		1052	580	552	55.2	44.8

RESULTS OF INVESTIGATION OF THE CHIASMATA IN MONSTROUS SPECIMENS OF *Salvelinus fontinalis*.

Double monsters among trout fry are of common occurrence. These vary greatly in the degree and kind of malformation. The specimens used for this investigation varied from those having two heads and one body to those with heads and bodies entirely distinct but with a yolk sac in common. For convenience the individuals have been placed in four groups.

Group I includes the double-headed specimens which were divided only anterior to the dorsal fin.

Group II includes double-headed specimens which were divided posterior to the dorsal fin, but had a portion of the vertebral column in common.

Group III includes specimens in which the two bodies were united throughout a portion or the whole of the tail region, but were elsewhere distinct.

Group IV includes specimens with two young entirely distinct and on opposite sides of the yolk sac.

The bearing which these dicephalous specimens have upon the subject under discussion can be shown by briefly considering some of the theories advanced and some of the results obtained by those who have made a study of this condition. Among other causes of dicephaly, polyspermy has been advanced by several writers as a probable cause. If this occurred, it is evident that the heredity of these monstrosities would be more complicated than that of normal individuals.

Schmitt (**:02**), in a paper on the gastrulation of double trout embryos, stated that the germinal area of the egg which produced a double embryo was no larger, and contained no more material, than the one which gave rise to a normal trout. In the formation of the gastrula two invaginations occurred simultaneously in different parts of the blastoderm. This observation indicates that polyspermy had not occurred; for if it had occurred, there would have been an increase in the material contained in the germinal area. This change would also occur if the egg were fertilized by a double-headed sperm, one of the tentative causes for duplicity advanced by some writers.

Hans Spemann (**:01**, **:01^{a}**), in experimenting with the eggs of the salamander Triton, was able to produce dicephalous individuals, or even two distinct individuals, by means of a ligature of hair tied across the blastoderm. The extent of the duplicity depended on the tightness of the ligature. A similar result has been obtained by Loeb and others, although by different methods.

From these various observations it is evident that an increase in the amount of sperm, either by polyspermy or otherwise, is not, at least commonly, the cause of dicephaly. Accordingly in two-headed trout, the hereditary characters of the divided parts should be the same. It would follow, then, that if the dimorphic condition is hereditary, the condition of the crossing should be the same in each head. By referring to Table VIII, it will be seen that in more than one half of the double-headed specimens dissected the crossings in the two heads were opposite. This is very significant, for it indicates that the dimorphic condition of the chiasma is not hereditary. If heredity is not a factor, what does determine the crossing of the nerves in the chiasmata? In attempting to answer this question some other possible factors were examined, but with negative results.

TABLE VIII.

Results obtained from Dissection of Monstrous Specimens of *Salvelinus fontinalis.*

Group.	Right Nerve Dorsal in Both Heads.	Left Nerve Dorsal in Both Heads.	Right Dorsal in one Head, Left in the other.	Per cent R + R.	Per cent L + L.	Per cent R + L.
I.	24	8	21	45.0	16.0	39.0
II.	10	6	25	24.4	14.7	60.9
III.	10	4	23	27.0	11.0	62.0
IV.	11	7	22	27.5	17.5	55.0
Total	55	25	91	32.2	14.6	53.2

Results from Study of the Development of the Optic Nerve.

Histological investigation was made of the optic nerves in different stages of development. For this purpose eggs were brought from the hatchery at Wilkinsonville, Massachusetts, and kept in a trough of running water. Eggs were taken each day and fixed in Vom Rath's fluid, which proved to be the best fixative for this purpose. As is well known, the great majority of nerve fibres in the optic nerve develop from the retinal cells and grow backward to the brain. The object of this investigation was not, however, to study the mode of development, but rather to find out whether both nerves developed at the same time. In nearly all cases the nerve fibres had reached the brain by the tenth day. Whenever the nerve fibres could be traced, they developed at the same time, for the fibres from both eyes were equally developed. The dimorphism is not due to an earlier development of one of the optic nerves.

The Effect of Gravity upon the Crossing of the Optic Nerves.

O. Schultze ('95) in some experiments with frogs' eggs, found by compressing the eggs between glass plates so as to force the blastoderm to remain at some point other than its normal one, that he produced abnormal specimens. The degree of abnormality varied according to the angle made by the axis of the normal egg with the attraction of gravity. I have carried on similar experiments with eggs of the brook trout, but with no results so far as abnormalities were concerned. The compressed eggs died within a week or ten days. But the experiments showed conclusively that gravity could have no effect on the development of the nerves, and therefore could not cause the dimorphism; for in all cases the blastoderm finally came to the top of the egg, in spite of the pressure. If the blastoderm remained at the top under such conditions, it certainly would do the same under normal conditions. In this position the effect of gravity on the two sets of developing nerve fibres would be the same, and consequently gravity could not be a factor in the question under consideration.

The Laws of Chance applied to the Results.

The writer has now shown that the dimorphism under consideration is not hereditary, is not due to an earlier development of one of the optic nerves, and is not caused by the action of gravity. It seems to be begging the question to say that it is a matter of chance whether one nerve is uppermost or not; for this means that the real cause of the dimorphic condition is unknown and, whatever it may be, it was not affected by the conditions of the experiments performed. Admitting that a "chance result" has this significance, the writer wishes to show that the results obtained from the dissections are really chance results. If so, the chances would be equal, in the normal trout, that either the right or the left nerve should be uppermost. In other words, the so-called rights and lefts should occur in equal numbers. Referring to the results obtained from the first and second generations of the trout, and to the control lot, also to the results obtained from the cod, it will be seen that the observed results closely approximate such a relation. Of Salvelinus, 4950 specimens in all were dissected. Of these, 2749 had the right nerve dorsal, and 2201 the left nerve dorsal. Of Gadus, 1132 specimens were dissected; 580 of these had the right nerve dorsal, and 552 the left nerve. In both cases, but especially in the first, there is an excess of rights. In view of the results obtained from the selected matings, this excess cannot be regarded as very significant. In the case of the trout, where it was greater than in the cod, it amounts to six per cent only.[1]

In the case of the two-headed trout the conditions are more complicated. In these, three combinations are possible. Either the right or the left nerve may be dorsal in each head, or the right nerve dorsal in one head, the left nerve dorsal in the other. According to the laws of chance, in one half of the specimens the crossings in the two heads should be unlike, while in the other half the crossing should be similar in the two heads. Further, of those having the crossings similar, one half should have the right nerve dorsal in each head, the other half the left nerve dorsal. Of the 171 two-headed trout dissected, 85 approximately should have crossings opposite in the two heads, and 42 each should have the right or the left nerve dorsal in both heads. Actually, 91 had the crossings opposite, 55 had the right nerve dorsal in both heads, and 25 the left nerve dorsal in both heads. Adding the last two groups together, the numbers of those having the crossings similar and of those with the crossings opposite are almost exactly equal, yet the right nerve, as in other categories of cases, is oftener uppermost than the left one. This fairly close correspondence with the expected chance result leads the writer to the conclusion that the position of the optic nerves in the chiasmata of the symmetrical teleosts is a matter of chance and not due to any of the possible causes which have been discussed in this paper.

Summary.

1. The Mendelian principles of heredity do not apply to the dimorphic condition of the optic chiasma in symmetrical teleosts.
2. Galton's law likewise is inapplicable.
3. The dimorphic condition is not inherited.
4. The dimorphism is not due to an earlier development of one of the optic nerves.
5. Gravity has no effect on the character of the crossing of the optic nerves.
6. The condition of the crossing is a matter of chance.

---

[1] *Note by W. E. Castle.* It is, however, somewhat remarkable that in both species studied the rights should with such uniformity predominate, even though the excess is not great. Selected matings evidently do not affect the relation one way or the other, but it persists nevertheless in nearly all matings and in the control. The case may perhaps belong in the same category as the more frequent occurrence of polydactylism in guinea-pigs upon the left side of the body (Castle, :**06**).

BIBLIOGRAPHY.

Castle, W. E.

:06. The Origin of a Polydactylous Race of Guinea-pigs. Carnegie Institution of Washington, Publication No. 49, pp. 17–29.

Galton, F.

'89. The Average Contribution of each Several Ancestor to the Total Heritage of the Offspring. Proc. Roy. Soc., London, Vol. 61, pp. 401–413.

Parker, G. H.

:03. The Optic Chiasma in Teleosts and its Bearing on the Asymmetry of the Heterosomata. Bull. Mus. Comp. Zoöl. Harvard Coll., Vol. 40, No. 5, pp. 219–242, 1 pl.

Schmitt, F.

:02. Über die Gastrulation der Forelle mit Berücksichtigung der Concrescenztheorie. Verhandl. d. deutsch. Zool. Gesellsch., 12te Jahresversammlung, Leipzig, pp. 64–83, 7 Fig.

Schultze, O.

'95. Die künstliche Erzeugung von Doppelbildungen bei Frosch Larven mit Hilfe abnormer Gravitations-wirkung. Arch. f. Entwickelungsmech., Bd. 1, pp. 269–305, Taf. 11 u. 12.

Spemann, H.

:01. Experimentelle Erzeugung zweiköpfige Embryonen. Sitzungsb. d. phys.-med. Gesellsch. Würzburg, Jahrg. 1900, pp. 2–9.

Spemann, H.

:01^a. Entwickelungsphysiologische Studien am Triton-Ei. Arch. f. Entwickelungsmech., Bd. 12, pp. 224–264, Taf. 5, 24 Textfig.